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Making Vehicle Emissions Inspection Effective — Learning from Experience in India

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For controlling emissions from in-use vehicles, governments rely on emissions inspection programs with varying success. The most extensive program of this type found in South Asia is Pollution Under Control (PUC) in India. An emissions specialist who has been closely involved in the development of the vehicle emissions inspection program in Mexico City visited Bangalore, Delhi, Mumbai and Pune in India in August and September of 2002 to assess the PUC program and make recommendations for its improvement.

Repairing gross polluters to lower vehicular emissions should be one of the most effective means of addressing transport-related air pollution. But identifying high emitters and ensuring that they are properly repaired is not easy. General lessons about how to mount effective vehicle emissions inspection programs can be found in [1] and [2].

In South Asia, Bangladesh and Sri Lanka are only now developing a vehicle emissions inspection program, and Pakistan has test centers on a trial basis. Nepal has been operating centralized emissions inspection test centers for three- and four-wheelers in the Kathmandu Valley since 1996, supplemented by roadside inspections. Bhutan plans to start an emissions testing program in January 2003 to complement its vehicle safety and roadworthiness inspection program. India has had a nation-wide inspection program since the 1980s, called Pollution Under Control (PUC)[1]. Therefore, it would be useful to review the PUC program, see what lessons can be learned, and consider what changes would be required to make it more effective. This briefing note summarizes the findings of such an assessment [3].

Current PUC Administration

The responsibility for setting up and administering the PUC program is divided between national and state authorities. The Central Pollution Control Board (CPCB) and the Central Ministry of Road Transport and Highways are responsible for the equipment and test protocol specifications and for publishing the emissions limits. The limits of 4.5% for carbon monoxide (CO) for two- and three-wheelers, 3% CO for all other spark-ignition vehicles, and an opacity limit for all diesel vehicles of 65 Hartridge smoke units (HSU) were established in 1986 and have not been revised since. There is a proposal to tighten the CO limits (including a maximum of 0.5% CO for four-wheel vehicles with closed-loop three-way catalytic converters) and introduce hydrocarbon (HC) limits for spark-ignition vehicles manufactured after April 2000 and equipped with catalytic converters.

Program implementation itself is left up to each state, which has to meet the minimum requirements specified by the central government. The local State Pollution Control Board (SPCB) and Ministry of Road Transport and Highways can implement a stricter program if they so desire. Nationally, every vehicle is required to be tested twice a year, and in Delhi four times a year.

Test centers

Any company that owns an automotive workshop or a filling station can apply to become a PUC center. The requirements for setting up a center are lenient, and there is little supervision of PUC centers, which can be mobile or fixed units. Although intended to be test-only centers in principle, the PUC centers in practice are permitted to conduct minor engine adjustments to get vehicles through the test. Test fees vary from city to city, ranging from about Rs 20 (approximately US$0.40) for two-wheelers to about Rs 70 for trucks. There is no control on the number of approved centers.

Even though there are still not enough test lanes to carry out the mandatory number of tests, there are too many

[1] ***Inspection and maintenance*** refers to a vehicle emissions control system where *both* the emissions inspection *and* the vehicle maintenance programs are controlled by the government (as in California). PUC in India is a vehicle emissions inspection system. The term "***inspection and certification***" (I&C) is used in India to refer to a more formally structured and rigorous vehicle emissions inspection program, under governmental control, that is applied to the more highly polluting vehicle segments to certify the vehicles' compliance with the emission standards, but the government does not supervise the maintenance process directly.

centers to supervise given the number of enforcement officers. The problems found at test centers include a serious lack of technician training and established operating and test procedures; the absence of independent audits; poor or no calibration of equipment; and near-absence of penalties so that centers can issue fraudulent certificates with impunity. Test centers are required to have an annual maintenance contract with their equipment supplier that includes instrument calibration every six months. In practice, very few centers have contracts because of the cost. There is no government calibration audit program in place. None of the centers visited during this assessment study had calibration gases or filters.

Certificates

The government does not control issuance of certificates. In Delhi, each center prints its own certificates and windshield stickers. In other cities, associations of test center owners coordinate the printing of certificates and stickers for their members. No document or information is generated by the centers for government use or supervision. The windshield stickers are not designed to facilitate enforcement: their graphic design does not vary from period to period, making it very difficult for an enforcement officer to differentiate between a valid and outdated sticker.

Test procedures

For spark-ignition engine vehicles (gasoline and gaseous fuels), the vehicle exhaust is tested by measuring concentrations of CO at low idle (normally between 600 and 1,200 engine revolutions per minute, rpm). HC/CO two-gas analyzers certified to measure only CO are used. Other gases or rpm are not measured. The decision over when and how the measurement readings are to be taken is left to each individual tester.

One significant shortcoming of this test procedure, often negating the validity of the measurements, is that gas dilution is not controlled. Diluting the exhaust gas with clean air—easily achieved by partially withdrawing the probe from the exhaust pipe—lowers the readings and enables dirty vehicles to pass fraudulently. Furthermore, tail-pipe extension tubes are not used with two- and three-wheelers so that it is virtually impossible to insert the probe sufficiently into the exhaust pipe to avoid air entrainment. The only way to prevent gas dilution is to require measurements of oxygen (O_2) and carbon dioxide (CO_2) to correct the readings and to specify threshold values outside of which the test is automatically invalidated. Hence, as India moves to mandating limits on CO and HC for spark-ignition engine vehicles, four-gas (CO, HC, CO_2 and O_2) analyzers certified for all the four gases should be used in idle tests.

Equally serious, spark-ignition vehicles are tested at low idle. All the two- and three-wheelers and the vast majority of four-wheelers are carbureted. This means that both CO and HC levels can be lowered by tuning the air/fuel mixture "lean" (high air-to-fuel ratio) and/or by retarding the ignition timing. This "late and lean" tuning was historically used extensively in Mexico City and California by owners of polluting vehicles just to pass the test. Tuning late and lean also increases nitrogen oxide emissions, but since they are not measured, this temporary tuning cannot be detected by the current test method. Often, the vehicle engine is tuned back to its former state right after passing the test because tuning late and lean can lead to unacceptable loss of power. As such, this test procedure cannot achieve the primary objective of an inspection program: to identify for repair poorly maintained and polluting vehicles. The only way to close this loophole is to test vehicles on a dynamometer and impose limits on nitric oxide (NO) in addition to CO and HC. This would require, in addition to installing dynamometers at test centers, five-gas analyzers certified for CO, HC, NO, O_2 and CO_2.

For diesel vehicles, a snap acceleration smoke test is currently being used. The present test procedure is not capable of generating reproducible results. Other problems associated with smoke measurements are treated separately in Briefing Note No. 10 [4]. As in the case of spark-ignition vehicles, dilution of the exhaust gas with clean air can lower smoke readings.

Data transfer and recording

All the data are manually recorded. Technicians can therefore record numbers different from the actual readings, or as happens frequently, record "test results" without turning the analyzer on. For the small percentage of vehicles that have a current PUC certificate, this is believed to be one of the principal means of obtaining it.

PUC supervision

Good quality assurance and quality control (QA/QC), essential for any successful program, requires a well-trained staff with information technology systems in place that both facilitate technical accuracy and minimize opportunities for corruption. It also requires a development program to design and implement modifications to test protocols, operating procedures and emission standards as needed. There are only four inspectors in Delhi to visit each of the 430 centers on a bimonthly basis to check their operations—this is clearly not physically possible.

Vehicle enforcement

Enforcement of PUC is virtually non-existent, in part because of lack of resources. As a result, the majority of vehicles in India have never had a PUC test or certificate, including most two-wheelers in Delhi. Detailed information on the size and the composition of the vehicle population is not readily available, as private vehicles are required to report to the authorities only 15 years after the first registration. Vehicle retirement is poorly recorded, so that information about old vehicles—one of the primary targets of PUC—is particularly inaccurate. These factors contribute to vehicle owners not feeling compelled to comply.

Recent Developments

The Society of Indian Automobile Manufacturers (SIAM) has been engaged in an initiative to improve PUC, primarily focusing on automated data entry. SIAM's software can take CO readings from as many as 10 different makes of analyzer and prints the certificate which includes a photograph of the number plate. This will require that at a minimum the vehicles actually show up at a test center. SIAM recommends requiring PUC centers to possess extension tubes for the two- and three-wheelers. At the moment, SIAM's software is not designed to control the analyzer or the length of the test, and does not include those functions necessary for QA/QC, such as calibration control, auto-zero and residual checks. SIAM intends to add a data transmission module at a later stage so that each center can send daily results to the main SIAM server via the Internet.

SIAM has installed its computerized data collection system at over 100 test centers in Bangalore. The response of the public as well as test center owners has been very positive, enhancing PUC's credibility.

There is new test development underway. The Automotive Research Association of India (ARAI) is in the process of developing a simplified dynamic test for two-wheelers that simulates the Indian drive-cycle. The test uses a simple free-roll dynamometer and current PUC instrumentation.

In order to ensure that vehicles actually report to test centers, there are proposals to link the requirement of having a valid certificate to vehicle insurance payments nationally, and to annual tax in one state. The regulation requiring filling stations to limit fuel sale only to those vehicles that have a valid PUC certificate (the PUC windshield stickers do not have legal status at present) has not been effective, as this approach is operatively complicated and works against the commercial interest of filling station owners.

Conclusions and Recommendations

This assessment yields some general conclusions as well as recommendations for making the Indian PUC program more effective. The conclusions and recommendations are generalized as much as possible to apply to other countries.

Redesigning the testing centers

- Because of conflict of interest, test-and-repair garages should be phased out in favor of test-only centers.
- The inspection program should be designed to generate reasonable profits for test-only centers—by balancing the numbers of test centers and vehicles to be tested and allowing reasonable fees to be charged—to ensure sufficient incentive for the center owners to "police" themselves.
- The government should consider opening a public bid process—selecting, for example, two or three firms in large cities, and one in a medium size city—to operate all the centers for a limited time period.
- Rather than attempting to upgrade the PUC program for the entire country covering every vehicle, consideration may be given to concentrating limited resources on establishing an enhanced inspection and certification (I&C) system for those vehicles that are likely to contribute most to urban air pollution from mobile sources: high annual mileage gross polluters. It is important to design the system to overcome many of the shortcomings of the current PUC: to generate far more reproducible and accurate test results with strong QA/QC to minimize fraud. Video monitoring of each test lane should be considered in the I&C program. The remaining vehicles can continue to be covered under PUC with less stringent modifications.
- Another way of strengthening the inspection system while controlling costs would be to decrease the frequency of tests, especially for new, private spark-ignition vehicles that are expected to be relatively clean and accumulate low annual mileage.

Testing procedures

- To minimize false passes, a test protocol that is difficult to cheat on or bypass, and strong and rigorous audit and supervision schemes need to be established from the outset. The protocols should be capable of preventing temporary tuning that enables dirty vehicles to pass.
- In designing test protocols, substantially reducing measurement differences among test centers, and improving reproducibility and accuracy should be given a high priority.
- Dilution of gas during measurements should be tightly controlled to avoid entraining clean air into the exhaust gas, thereby lowering readings and making it more difficult to identify high emitters.
- International experience with spark-ignition vehicles has amply demonstrated that dynamometers are essential to minimize false passes. The dynamometer tests should set limits on NO as well as CO and HC.
- Readings should be taken after a pre-established time by a computer rather than at arbitrary moments convenient to the tester, as is currently the case. It is also recommended that the test results not be made available to the test technician until the computer has entered the results in the database, lest the tester intervenes to modify the results.
- The computer should control not only the data entry but also the gas measuring equipment used. This is the only way to ensure that automatic gas calibration and leak checks are correctly performed every three days at a minimum, and that ambient and residual gas values are within limits before allowing the instruments to be zero-referenced between tests. Such computer control can also be programmed to allow the instrument to be locked out if any functional problems are detected or if systematic calibration audits are not performed.

- Because of the inherent weaknesses of the test protocols that can be used in roadside checks of emission levels—lack of acceptable reproducibility and the complexity of adequately supervising their operation—roadside inspection should be phased out for the most part except as a screening tool to identify gross smoke emitters and send them to test centers.

The role of government

- Government must be willing and able to invest the resources, staff and effort in auditing and supervising the program to improve significantly its objectivity and transparency. A small number of multi-lane centers in the hands of a few companies are much easier to supervise than a large number of small test centers with diverse owners.
- Unduly strict standards that generate socially unacceptable failure rates, coupled with lax program supervision and enforcement, openly invite vehicle owners to obtain the certificate fraudulently. It is advisable to set emission standards for in-use vehicles that are achievable, with some effort, by a majority of vehicles, even if initially these standards may be relatively lenient. They can then be tightened over a period of time until the standards that are required to generate the desired air quality improvement are finally established.
- Updating the vehicle population database is one of the critical steps in making the vehicle-testing program more effective.
- Government should ensure that calibration audits are performed by independent accredited materials standard laboratories on each test lane, once every three months at PUC and once a month at I&C centers.
- There should be a readily identifiable indication of compliance by giving the PUC sticker the legal status of an official document and improving the PUC sticker design, making its validity readily identifiable by enforcement officers. Printing and administering pass certificates and stickers should be brought under central control.
- Computerized data entry and the adoption of centralized databases enable timely collection of the data required for the supervision process and for statistical analysis. The central government should define the database structure and auxiliary tables so that consistent information is produced across all test centers and state programs. Legally requiring the local authorities to publish on the Internet all the test results and accompanying databases within a well-defined timeframe would not only help in the supervision of the local authorities, but also ensure that the central government and others can utilize the data collected in a pro-active manner.
- It is recommended that a central agency be made responsible for developing and maintaining one software package (for data transfer, QA/AC, remote auditing and test operation) for all the test centers and for all makes of equipment.
- Local authorities monitoring test centers have been found to engage in fraudulent activities in other countries. Therefore, there should be some measure of supervision and compliance for the local enforcing authority. Government should seriously consider making use of remote auditing to distance their staff from the temptation of turning a blind eye to fraudulent practices in exchange for financial gain.
- There should be a legal framework for applying penalties to test centers found in violation of test protocols or engaging in fraudulent practices.
- As the enforcement of emission standards for in-use vehicles is strengthened, the black-market value of valid certificates will increase and owners of polluting vehicle will find new ways of getting around the inspection system. Government should be prepared for vehicle owners' response to increasingly stricter enforcement and be willing to change test procedures and security features frequently to keep one step ahead.

References

1. M. Kojima and R. Bacon. 2001. "Emission Control: Privatizing Vehicle Inspection and Reducing Fraud in Mexico City." Viewpoint 238, September. Available at <http://worldbank.org/html/fpd/notes/238/238summary.html>.
2. Asif Faiz, C.S. Weaver and M.P. Walsh. 1996. *Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions*. World Bank. See Chapter 4.
3. John Rogers. 2002. *Assessment of the Pollution Under Control Program in India and Recommendations for Improvement*, prepared for the World Bank, October. Available at <http://www.worldbank.org/sarurbanair>.
4. South Asia Urban Air Quality Management Briefing Note No. 10. 2002. "Tackling Emissions from In-Use Diesel Vehicles," November. Available at <http://www.worldbank.org/sarurbanair>.

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A full set of briefs and other materials are available at <http://www.worldbank.org/sarurbanair>.

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